

WHAT IS CLAIMED IS:

1. A demodulation device comprising:

5 a Fourier transform unit (1) for performing a Fourier transform on a received OFDM signal to output a subcarrier component obtained as a result of the Fourier transform;

a pilot signal-extracting unit (3) for extracting a pilot signal contained in said subcarrier component output from said Fourier transform unit (1);

10 a known signal generating unit (4) for generating and outputting a known signal corresponding to said pilot signal;

a first divider unit (5) for dividing said pilot signal output from said pilot signal-extracting unit (3) by said known signal output from said known signal generating unit (4) to calculate a transmission channel characteristic corresponding to said pilot signal;

15 a delay profile estimation unit (7, 12) for estimating a delay profile based on said transmission channel characteristic of said pilot signal output from said first divider unit (5), and outputting a signal corresponding to a maximum delay time in said delay profile and a signal corresponding to a minimum delay time in said delay profile;

20 an interpolation filter unit (18) for performing interpolation on said transmission channel characteristic of said pilot signal output from said first divider unit (5) along a time axis and along a frequency axis, and outputting a transmission channel characteristic corresponding to said subcarrier component;

a timing synchronization unit (2, 13) for outputting a timing signal that controls timing for performing Fourier transform in said Fourier transform unit (1) based on a
25 signal corresponding to said minimum delay time output from said delay profile

estimation unit (7, 12) and said OFDM signal; and

a second divider unit (10) for dividing said subcarrier component output from said Fourier transform unit (1) by a transmission channel characteristic corresponding to said subcarrier component output from said interpolation filter unit (18), to output a demodulated signal, wherein

said Fourier transform unit (1) performs said Fourier transform according to said timing signal; and

said interpolation filter unit (18) sets a pass band of a frequency interpolation filter used for said frequency axis interpolation based on said signal corresponding to said maximum delay time, and restricts a frequency band of said transmission channel characteristic corresponding to said subcarrier component while it is being output.

2. The demodulation device according to claim 1, wherein

said delay profile estimation unit (12) outputs said signal corresponding to said maximum delay time and said signal corresponding to said minimum delay time based on a transmission channel characteristic obtained after said transmission channel characteristic of said pilot signal has been interpolated along the time axis.

3. A demodulation device comprising:

a Fourier transform unit (1) for performing a Fourier transform on a received OFDM signal to output a subcarrier component obtained as a result of the Fourier transform;

a phase rotation unit (14) for rotating and outputting a phase of said subcarrier component output from said Fourier transform unit (1);

a pilot signal-extracting unit (3) for extracting a pilot signal contained in said

subcarrier component output from said phase rotation unit (14);

a known signal generating unit (4) for generating and outputting a known signal corresponding to said pilot signal;

5 a first divider unit (5) for dividing said pilot signal output from said pilot signal-extracting unit (3) by said known signal output from said known signal generating unit (4) to calculate a transmission channel characteristic corresponding to said pilot signal;

10 a delay profile estimation unit (7, 12) for estimating a delay profile based on said transmission channel characteristic of said pilot signal output from said first divider unit (5), and outputting a signal corresponding to a minimum delay time in said delay profile and a signal corresponding to a minimum delay time in said delay profile;

15 an interpolation filter unit (18) for interpolating said transmission channel characteristic output from said first divider unit (5) along a time axis and a frequency axis to calculate a transmission channel characteristic corresponding to said subcarrier component;

a phase adjustment amount-calculating unit (15) for outputting an amount of phase rotation in said phase rotation unit based on said signal corresponding to said minimum delay time output from said delay profile estimation unit (7, 12); and

20 a second divider unit (10) for dividing said subcarrier component the phase of which has been rotated in said phase rotation unit (14) by a transmission channel characteristic corresponding to said subcarrier component output from said interpolation filter unit to output a demodulated signal, wherein

25 said phase rotation unit (15) rotates the phase of said subcarrier component by the amount of phase rotation output from said phase adjustment amount-calculating unit (15); and

said interpolation filter unit (18) sets a pass band a frequency interpolation filter used for interpolation along said frequency axis based on said signal corresponding to said maximum delay time and outputs said transmission channel characteristic corresponding to said subcarrier component while restricting its frequency band.

5

4. The demodulation device according to claim 1 or 2, further comprising:
a phase rotation unit (16) for rotating a phase corresponding to said subcarrier component output from said Fourier transform unit (1) by an amount of phase rotation determined based on a guard interval length and a frequency of said subcarrier component, wherein

10 said pilot signal-extracting unit (3) extracts a pilot signal from said subcarrier component the phase of which has been rotated by said phase rotation unit (16);

 said delay profile estimation unit (7, 12) outputs a signal corresponding to an average value of a maximum delay time and a minimum delay time in said delay profile;
and

15 said timing synchronization unit (2, 13) outputs a timing signal based on a signal corresponding to said average value.

5. The demodulation device according to claim any one of claim 1 through 3,
wherein

20 said delay profile estimation unit (7, 12) comprises:

 a signal sorting unit (71, 121) for sorting said transmission channel characteristics that have been input in an ascending order or a descending order of frequency and outputting said transmission channel characteristics;

 an inverse Fourier transform unit (72, 122) for performing an inverse Fourier
25 transform on said transmission channel characteristics output from said signal sorting unit

(71, 121) and outputting a signal corresponding to a result of said inverse Fourier transform;

a relative level-calculating unit (73, 123) for calculating and outputting a power value in said delay profile based on an amplitude of said signal output from said inverse Fourier transform unit (72, 122);

an incoming wave determining unit (74, 124) for determining a component corresponding to said power value to be a component corresponding to an incoming wave if said power value output from said relative level-calculating unit (73, 123) is equal to or greater than a predetermined threshold value, and outputting, as a delay time of said incoming wave, a time difference between timing for performing a Fourier transform in said Fourier transform unit (1) and a tail end of a guard period in said incoming wave;

a maximum delay time calculating unit (75, 125) for outputting a signal corresponding to a maximum delay time among said delay time output from said incoming wave determining unit (74, 124); and

a synchronization timing offset-calculating unit (76, 126) for outputting a signal corresponding to a minimum delay time among said delay time output from said incoming wave determining unit (74, 124).

6. The demodulation device according to claim 4, wherein
said delay profile estimation unit (7, 12) comprises:

a signal sorting unit (71, 121) for sorting said transmission channel characteristics that have been input in an ascending order or a descending order of frequency and outputting said transmission channel characteristics;

an inverse Fourier transform unit (72, 122) for performing an inverse Fourier transform on said transmission channel characteristics output from said signal sorting unit

(71, 121) and outputting a signal corresponding to a result of said inverse Fourier transform;

a relative level-calculating unit (73, 123) for calculating and outputting a power value in said delay profile based on an amplitude of said signal output from said inverse Fourier transform unit (72, 122);

an incoming wave determining unit (74, 124) for determining a component corresponding to said power value to be a component corresponding to an incoming wave if said power value output from said relative level-calculating unit (73, 123) is equal to or greater than a predetermined threshold value, and outputting, as a delay time of said incoming wave, a time difference between timing for performing a Fourier transform in said Fourier transform unit (1) and a tail end of a guard period in said incoming wave;

a maximum delay time calculating unit (75, 125) for outputting a signal corresponding to a maximum delay time among said delay time output from said incoming wave determining unit (74, 124); and

a synchronization timing offset-calculating unit (76, 126) for outputting a signal corresponding to a minimum delay time among said delay time output from said incoming wave determining unit (74, 124).

7. The demodulation device according to claim 5, wherein

said relative level-calculating unit (73, 123) calculates a delay time-to-signal power value based on an amplitude or squared amplitude of a signal output from said inverse Fourier transform unit (72, 122) and outputs said delay time-to-signal power value as said power value.

8. The demodulation device according to claim 6, wherein

said relative level-calculating unit (73, 123) calculates a delay time-to-signal power value based on an amplitude or squared amplitude of a signal output from said inverse Fourier transform unit (72, 122) and outputs said delay time-to-signal power value as said power value.

5

9. The demodulation device according to claim 5, wherein
said transmission channel characteristic input to said delay profile estimation unit (7, 12) is a transmission channel characteristic corresponding to a pilot signal.

10

10. The demodulation device according to claim 6, wherein
said transmission channel characteristic input to said delay profile estimation unit (7, 12) is a transmission channel characteristic corresponding to a pilot signal.

15

11. The demodulation device according to claim 5, wherein
said transmission channel characteristic input to said delay profile estimation unit (7, 12) is a transmission channel characteristic after said transmission channel characteristic corresponding to a pilot signal has been interpolated along the time axis.

20

12. The demodulation device according to claim 6, wherein
said transmission channel characteristic input to said delay profile estimation unit (7, 12) is a transmission channel characteristic after said transmission channel characteristic corresponding to a pilot signal has been interpolated along the time axis.

25

13. The demodulation device according to claim 1, wherein
said timing synchronization unit (2, 13) comprises:

an autocorrelation calculating unit (26) for calculating and outputting an autocorrelation of said OFDM signal based a guard interval in said received OFDM signal;

5 a correlation maximum point-detecting unit (24) for detecting a maximum value of output from said autocorrelation calculating unit (26) and a first timing signal for controlling timing of said Fourier transform based on said maximum value; and

a timing offset adjusting unit (25) for adding an offset to said first timing signal based on said signal corresponding to said minimum delay time and output said timing signal.

10

14. The demodulation device according to claim 3, wherein

said timing synchronization unit (2, 13) comprises:

15 an autocorrelation calculating unit (26) for calculating and outputting an autocorrelation of said OFDM signal based a guard interval in said received OFDM signal;

a correlation maximum point-detecting unit (24) for detecting a maximum value of output from said autocorrelation calculating unit (26) and a first timing signal for controlling timing of said Fourier transform based on said maximum value; and

20 a timing offset adjusting unit (25) for adding an offset to said first timing signal based on said signal corresponding to said minimum delay time and output said timing signal.

15. The demodulation device according to claim 1, wherein

said timing synchronization unit (2, 13) comprises:

25 an effective symbol length delay unit (21) for delaying said received OFDM

signal by a data interval length subjected to said Fourier transform and outputting a delayed OFDM signal;

a complex multiplication unit (22) for calculating a complex multiplication of said OFDM signal and a complex conjugate signal of said delayed OFDM signal and a
5 complex signal corresponding to a result of the calculation;

a moving average-calculating unit (23) for calculating a moving average for a predetermined interval length of said complex signal output from said complex multiplication unit (22);

a correlation maximum point-detecting unit (24) for detecting, based on a
10 signal output from said moving average-calculating unit (23), a position in said predetermined interval length at which an amplitude of said complex signal becomes maximum, and generating a first timing signal for controlling timing of said Fourier transform based on said position; and

a timing offset adjusting unit (25) for adding an offset to said first timing signal
15 based on said signal corresponding to said minimum delay time, and outputting said timing signal.

16. The demodulation device according to claim 3, wherein

said timing synchronization unit (2, 13) comprises:

20 an effective symbol length delay unit (21) for delaying said received OFDM signal by a data interval length subjected to said Fourier transform and outputting a delayed OFDM signal;

a complex multiplication unit (22) for calculating a complex multiplication of said OFDM signal and a complex conjugate signal of said delayed OFDM signal and a
25 complex signal corresponding to a result of the calculation;

a moving average-calculating unit (23) for calculating a moving average for a predetermined interval length of said complex signal output from said complex multiplication unit (22);

5 a correlation maximum point-detecting unit (24) for detecting, based on a signal output from said moving average-calculating unit (23), a position in said predetermined interval length at which an amplitude of said complex signal becomes maximum, and generating a first timing signal for controlling timing of said Fourier transform based on said position; and

10 a timing offset adjusting unit (25) for adding an offset to said first timing signal based on said signal corresponding to said minimum delay time, and outputting said timing signal.

17. A demodulation method comprising:

15 a Fourier transform step of performing a Fourier transform on a received OFDM signal to output a subcarrier component obtained as a result of the Fourier transform;

a pilot signal-extracting step of extracting a pilot signal contained in said subcarrier component output in said Fourier transform step;

20 a known signal generating step of generating and outputting a known signal corresponding to said pilot signal;

a first division step of dividing said pilot signal output in said pilot signal-extracting step by said known signal output in said known signal generating step to calculate a transmission channel characteristic corresponding to said pilot signal;

25 a delay profile estimation step of estimating a delay profile based on said transmission channel characteristic of said pilot signal output in said first division step,

and outputting a signal corresponding to a maximum delay time in said delay profile and a signal corresponding to a minimum delay time in said delay profile;

an interpolation step of performing interpolation along a time axis and along a frequency axis based on said transmission channel characteristic of said pilot signal output in said first division step, and outputting a transmission channel characteristic corresponding to said subcarrier component;

a timing synchronization step of outputting a timing signal for controlling timing of said Fourier transform in said Fourier transform step based on a signal corresponding to said minimum delay time output from said delay profile estimation step and said OFDM signal; and

a second division step of dividing said subcarrier component output in said Fourier transform step by a transmission channel characteristic corresponding to said subcarrier component output from said interpolation filter unit to output a demodulated signal, wherein

said Fourier transform in said Fourier transform step is performed according to said timing signal; and

in said interpolation step, a pass band of a frequency interpolation filter used for said frequency axis interpolation is set based on said signal corresponding to said maximum delay time, and a frequency band of said transmission channel characteristic corresponding to said subcarrier component is restricted while it is being output.